RESEARCH CIRCULAR 206 APRIL 1975

Twenty-Year Survival and Growth of Sugar Maple in Ohio Seed Source Tests

H. B. KRIEBEL

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER
WOOSTER, OHIO

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INTRODUCTION

Seed source tests of sugar maple (*Acer saccharum* Marsh.) were started in Ohio in 1954 to study the effects of geographic origin of the seed on survival, growth, and other characteristics. Various publications have reported the experimental procedures and results obtained in the nursery and at early ages in the six field tests (1, 2, 3, 4, 5, 6).

This report summarizes the results at age 20 in four field tests, two in northern Ohio and two in southern Ohio. Plantation L-15 in northern Ohio (Wayne County near Wooster) includes trees from 30 sources, of which 21 are replicated in Plantation SE-1 in southern Ohio (Meigs County near Carpenter). Plantation L-16 is adjacent to L-15 at Wooster. It includes a test of trees from three sources in the southern ecotype of sugar maple, a supplementary test of three of the four Ohio seed sources, and a test of three widely separated Ontario sources. The southern selections are replicated in plantation SE-2 at Carpenter. In all, the experiments include 603 trees in the Wooster plantings and 342 trees in the Carpenter plots.

Site conditions are more favorable for tree growth on the fertile Wooster silt loam than on the severely eroded Muskingum silt loam of southeastern Ohio. The objective of the tests at Carpenter was to determine whether any available genetic material was suitable for planting under these adverse but common conditions.

METHODS

The trees were transplanted into the field at age 4 in northern Ohio and at age 5 in southern Ohio. Replacements of initial losses were made during the first three dormant seasons after planting in northern Ohio and the first two dormant seasons in southern Ohio.

Measurements were made during the dormant season after 20 growing seasons from the time of seed germination. Repeated winter dieback and sprouting of many trees precluded height and diameter measurements of trees of the southern sources.

Significance tests of differences among sources of sugar maple ("F" tests) are not meaningful for interpretation of range-wide genetic variation because of the partly continuous nature of variation in most charac-

*Professor, Dept. of Forestry, Ohio Agricultural Research and Development Center, Wooster.

ters (2). The 20-year data were therefore compiled as ranked comparisons of source means. The consistency of rankings in relation to similar comparisons at earlier ages provided a basis for judging the validity of source differences.

Statistical evaluation was made, however, of differences in height and diameter among trees of the three Ohio sources (Ashtabula, Wayne, and Logan counties) in the supplementary test of local variation. To

TABLE 1.—Survival, Height, and Diameter at Age 20 in Wooster and Carpenter Sugar Maple Plantations L-15 and SE-1 (Northern and Central Ecotypes).

Seed Source (County, State, or Province)	Wooster			Carpenter		
	Survival Percent	Mean Height, Ft.	Mean DBH, In.	Survival Percent	Mean Height, Ft.	Mean DBH, In.
McLean, Ill	100	33	4 9	61	19	3 4
Warren, Pa	100	32	5 0	44	19	3 5
Ashtabula, Ohio	89	32	5 8	61	16	2 9
Wayne, Ohio*	100	32	4 8	78	16	2 4
Hancock, Ohio	94	31	4 6	67	16	2 3
Logan, Ohio	100	31	4 8	61	18	3 3
Brown, Ind	83	31	4 5			
Westmoreland, Pa	94	31	4 6	30	15	1 6
Middlesex, Conn	89	31	4 7			
Berkshire, Mass	75	31	4 4			
Cumberland, Nova Scotia	100	31	4 5	50	18	3 1
Lambton, Ont	94	30	4 3	17	17	1 6
Anderson, Tenn	92	30	4 3	56	16	2 2
Worcester, Mass	94	30	4 9	56	16	2 3
Somerset, Maine	80	30	4 0			
Onondaga, N Y.	94	30	4 6	33	17	2 0
Buncombe, N C.	100	29	4 2			
Litchfield, Conn	92	29	4 8			
Union, Ill	89	29	5 2	89	20	4 0
Bureau, Ill	83	28	4 0	67	14	1 8
Antrim, Mich	88	28	4 3	67	16	2 3
Marquette, Mich	82	28	4 2	44	16	2 1
Chittenden, Vt	100	28	4 0			
Hants, Nova Scotia	75	28	3 2			
Quebec, Quebec	86	28	3 0	33	8	0 7
Ingham, Mich	100	27	4 1	75	16	2 6
Clayton, Iowa	83	27	3 3	83	17	3 0
Van Buren Iowa	100	27	3 1	100	13	1 5
Highland, Va.	100	26	4 4	50	18	2 2
Webster, Iowa	100	26	3.1			
Mean of Common Sources	93	30	4.4	58	16	2 4

*Local source with respect to the Wooster plantation

compare results at different ages, regression analyses were run on tree height at age 6 vs. age 20 at Wooster, and at age 7 vs. age 20 at Carpenter.

RESULTS

Table 1 summarizes survival, height, and diameter breast high (DBH) (4½ feet above ground level) in tests L-15 and SE-1. The seed sources are ranked by their mean height growth at Wooster.

Northern Ohio

Excluding the southern ecotype, survival of trees of all sources was high in northern Ohio (Table 1 and Figure 1). There was no relation

FIG. 1.—Twenty-year-old sugar maple seed source plantation L-15 at the Ohio Agricultural Research and Development Center, Wooster.

TABLE 2.—Survival and Winter Injury at Age 20 in Wooster and Carpenter Sugar Maple Plantations L-16 and SE-2 (Southern Ecotype).

Seed Source (County, State)	Wooster		Carpenter	
	Survival Percent	Dieback* (Surviving Trees)	Survival Percent	Dieback (Surviving Trees)
Bibb, Ga.	100	Slight	83	Slight
Franklin, Miss.	70	Moderate	78	Moderate
Jackson, Fla.	30	Severe	17	Severe

*Slight = Up to one-third of crown dead. Moderate = One-third to two-thirds of crown dead. Severe = More than two-thirds of crown dead.

of survival rate to seed source, contrary to early response to severe drought conditions in the nursery at ages 1 and 2.

Mean height growth varied among sources from 33 to 26 feet or about ±10% of the plantation mean of 30 feet. Height growth was greatest in trees of mid-latitude origins from central Illinois to western Pennsylvania. It was intermediate in trees from extreme southern Illinois, Tennessee, southern Ontario, western New York, and southern New England. The lowest growth rate was found in trees of Iowa, Lake States, and northeastern Canadian sources. This was a continuation of the previously observed geographic pattern.

Diameter growth was more variable than height growth. Seed source means ranged from 5.8 to 3.0 inches, i.e., about ±32% of the plantation mean of 4.4 inches. There was no clear trend parallel to the trend of height growth, but a general conformity to the broad pattern of regional variation in height growth was apparent. Analysis of height and diameter in the separate test of Ohio sources showed that differences among sources were not significant.

The correlation between height at age 6 and age 20 was +0.52, based on individual tree measurements at both ages.

Table 2 summarizes the hardiness evaluation of southern trees in northern Ohio. Trees of Georgia origin were most winter-hardy. Trees of Mississippi origin were moderately winter-hardy. Trees of Florida origin were the least winter-hardy of all selections tested.

Southern Ohio

Survival rates were low in southern Ohio (Table 1). Of the 21 seed sources in Meigs County test SE-1, trees of only five sources had 75% or better survival by age 20. These sources were all in the Central States and southern Lake States. In general, low survival rate was characteristic of trees of the northern hardwood ecotype and moderate-to-high survival rate of trees of the central hardwood ecotype. These ecotypes are as described by Kriebel and Gabriel (6).

Overall, trees in the southern test had slightly more than half the growth rate of trees in the northern test (16 vs. 30 feet) when selections common to both tests were compared (Table 1). The best of the 21 seed sources in the southern locality continued to be extreme southern Illinois. Growth superiority, although slight at 20 years, has been consistent for this source during the entire life of the plantation. Trees of northern Ohio origin were no better than the plantation mean.

Diameter growth trends in southern Ohio were similar to height growth trends. The superiority of the southern Illinois trees in diameter as well as height is offset by their greater branchiness and poorer timber form, as previously noted (6).

The correlation between height at age 7 and age 20 was +0.26, i.e., half the correlation found in the northern test.

Winter mortality and winter injury of the southern selections (Table 2) were comparable to results in the northern test of these sources. Again, Georgia trees were most hardy, Mississippi trees intermediate, and Florida trees least hardy.

DISCUSSION

Seed source does not appear to be a critical factor in establishment and continued survival of planted sugar maple on good sites in northern Ohio.

Seed source selection is clearly critical for the commonly encountered poor-quality, old-field areas in southern Ohio. Very few geographic sources appear suitable. Selections from regions of warm dry summer climate as found in western parts of the species range are best adapted to these sites. This suggests that moisture stress is a limiting factor in source adaptability, as demonstrated in nursery experiments.

No conclusions can be made of the relative importance of plantation location vs. site quality to survival of sugar maple, since it was not possible to test a poor site in the north or a good site in the south. The higher summer temperature conditions in the south probably accentuated the adverse effects of poor site conditions in these experiments.

Selection for growth rate is, of course, secondary to selection for survival capacity. In northern Ohio, where there were no source differences in survival and site conditions were favorable, variation among seed sources in mean growth rate was not very large. A fairly wide choice of genetic material is therefore possible under these conditions. Since local (northern Ohio) selections were among the top-ranking ones, seed from local, native trees appears best for general use in northern Ohio. Use of McLean County, Illinois, seed can also be recommended because of the consistent superiority of these trees through the years.

In southern Ohio, sources with the best mean growth at age 20 did not always have the best survival rate. As in earlier evaluations, only the southern Illinois source was satisfactory from both standpoints. As noted, trees of this source have poor form and are not superior for timber production. Also, although these trees were the most vigorous in the southern test, their growth rate was only about two-thirds that of trees of the same source in the northern test.

The southern Illinois selection would, however, make a good ornamental or shade tree in either northern or southern Ohio. Desirable traits include its moderate growth rate, moderate branchiness or tendency to fork, and extreme summer and winter hardiness. In contrast, the Georgia, Mississippi, and Florida selections are of suitable size and form for ornamental use, but not sufficiently winter-hardy to be recommended.

It is clear that sugar maple cannot be selected for growth rate on the basis of early field performance at age 6 or 7. The relative growth rate of a tree was more consistent over the years in the north than in the south. But in neither test was the correlation between early and later growth rate high enough to provide a reliable estimate of future individual tree performance. Only one-third of the trees in the top 10% at age 6 at Wooster were in the top 10% at age 20. The results were similar to those found earlier in comparisons of 2nd and 9th-year growth and of 6th and 13th-year growth.

These experiments show that sugar maple plantations can be established and maintained successfully on good sites. Careful site and seed source selection is necessary because of the long rotation and high value of the timber crop. In northern Ohio, a local seed source (not more than 100 miles from the planting site) is recommended. In keeping with basic principles of genetic improvement, seed should be collected from stands of the highest available quality with respect to form and vigor.

SUMMARY

Seed source plantations of sugar maple in northern and southern Ohio were measured at the end of 20 years of growth from seed. Survival of trees of all but the most extreme southern sources was high on a good site in northern Ohio, whereas on a poor site in southern Ohio only trees from the western part of the species range had a high survival rate. On the productive northern site, local seed sources were among the best in height and diameter growth. On the eroded southern site, even the best geographic selections had a much lower growth rate than the same selections planted in the north. A selection from extreme

southern Illinois was the only one combining a high survival rate and moderate growth on the poor site. This selection can be recommended for amenity planting under these adverse conditions, but not for timber production.

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